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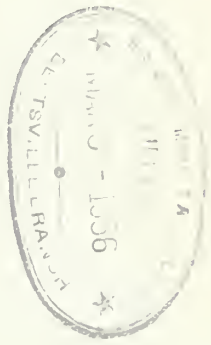

A METHOD OF DETERMINING PARTICLE SIZE OF LIQUEFIED-GAS AEROSOLS[1/]

By A. H. Yeomans

A satisfactory method of determining the particle size of liquefied-gas aerosols is to deposit a sample on a glass slide and measure the particles under a high-power microscope. The temperature of the formulation and dispenser has been made 80° F. to compare aerosol formulas, but at any temperature between 60° and 90° to determine the performance.

Preparation of Slide

The slide (1 by 3 inches) should be coated with an oleophobic substance that will cause the droplets to retain some of their convexity and prevent irregular spreading out on the slide. A satisfactory material is Dri-film 9987 (General Electric Co.).[2/] The slide is immersed in a cleaning solution, dried, immersed in the oleophobic-coating solution, and then after a few seconds lightly polished with a soft cloth. (Fumes from the Dri-film should not be breathed.) A slide coated with this material can be used for many samples, if it is washed with acetone after each use. When the droplets no longer remain circular, the slide should be recoated.

Deposition of Particles on Slide

The method of depositing the droplets on the slide depends on their size. For aerosols in which all the particles are less than 50 microns in diameter but the mass median diameter is more than about 8 microns,

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1/ This is a revision of ET-267, Directions for Determining Particle Size of Aerosols and Fine Sprays, issued by the former Bureau of Entomology and Plant Quarantine in May 1949. These investigations were conducted while the author was with that Bureau. He is now with the Biological Services Branch of the Agricultural Marketing Service.

2/ Mention of these manufacturers does not constitute endorsement of their products by the Department of Agriculture.

an impactor can be used (fig. 1). This impactor consists of a 2,000-c.f.m. ventilating fan which draws the aerosol through a tube 20 inches in diameter and 60 inches long. The aerosol is released at the center of one end of this tube so that it is carried toward the fan at the other end. About 42 inches from the release point and 18 inches in front of the fan, the slide is revolved on a 4-inch radius at 400 r.p.m. This is done by means of a counterbalanced holder for the slide turned by a variable-speed stirrer motor (Central Scientific Co. No. 18805).[2/] The optimum air flow and the speed of revolving the slide in this impactor were determined from many tests but are not critical.

The counterbalanced slide holder was constructed by cutting off two blades from a fan with blades 8 inches in diameter and then flattening the remaining two blades. On the end of one blade a copper slide holder was soldered, three edges of which were bent 1/16 inch over the face of the slide, so that the slide could be pushed in easily, and so that the 1-inch open end of the holder faced the release point of the aerosol. The slide revolved counterclockwise so that its exposed face was in the direction of rotation. The outside 3-inch edge was located ahead of the bottom edge, making a 25° angle between the face of the slide and the 4-inch turning radius, in order to minimize sliding of the droplets due to centrifugal action. The fan blade was cut in the center to a depth of 1/2 inch and the forward piece bent down before the holder was soldered so that the slide had a clear path to collect particles. A weight was soldered on the end of the other fan blade to balance the slide holder and slide.

The time the slide is exposed in the aerosol is important. If there are too many particles on the slide, some will be deposited on top of others and give a false reading. It was found best to expose the slide long enough for about 0.3-0.5 gram to be released. This was accomplished by attaching the variable-speed motor with the revolving slide on a swivel and lowering it from a well in the side of the tube down into the stream of aerosol.

The swivel was constructed of 1/4-inch pipe fastened to the inside of the 20-inch tube and serving as the axis. It was placed on the right side of the tube so that its center line was 3 1/2 inches below the horizontal center line of the tube, 1 inch inside the wall of the tube, with one end 10 1/2 inches from the fan. On this pipe axis a tee was attached loosely enough so that it could be turned; it was oiled periodically. On one side of this tee two pipes 4 inches long joined by a 90° elbow were attached. To the top pipe, which was parallel to the axis of the tube, the variable-speed motor was attached, and on the other side of the tee a handle for revolving it. This handle consisted of a pipe 2 1/2 inches long, a 45° elbow, a pipe 12 inches long, a 90° elbow, and a pipe 30 inches long. The 30-inch pipe was also parallel to the axis of the

20-inch tube and could be used to move the variable-speed motor while holding the aerosol dispenser. A hole was cut into the side of the drum to allow the revolving slide to be withdrawn. A slot was also cut in which the handle moved. No cover is needed for satisfactory operation.

Determination of Particle Size

After the aerosol has been deposited on a slide, it is placed under a microscope, and the particles are measured with an eyepiece micrometer having 50 divisions, each division equal to 15.4 microns. A 100-power microscope is best for particles of aerosol size. A mechanical stage on the microscope is necessary. The diameter as measured on the slide is then corrected for the spread that has taken place so that the diameter of the original sphere can be determined.

At least 200 particles should be measured. All the particles from one edge of the slide to the other are counted as the slide is moved by the mechanical stage. Representative data illustrating this method are given in table 1.

Table 1.--Size distribution of aerosol particles impinged on microscope slide.

Diameter (D) (scale divisions)	Number (N) of particles	DN	Percent of total DN	
			In each size	Accumulative
0.5	2	1	0.2	0.2
1.0	26	26	6.3	6.5
1.5	33	49.5	11.9	18.4
2.0	82	164	39.5	57.9
2.5	34	85	20.5	78.4
3.0	17	51	12.3	90.7
3.5	4	14	3.4	94.1
4.0	5	20	4.8	98.9
4.5	1	4.5	1.1	99.9
Total	204	415.0		

The diameter (D) is used in the first power only. The mass median diameter is computed on the basis of volume, which is in ratio to D^3, but the particles impinge in ratio to D^2. Therefore, the number of particles is multiplied by D^3/D^2, or by D.

The accumulative percentages are plotted on an arithmetic probability scale (No. 3127, Codex Book Company, Inc.).[2] The 50-percent point of the line so plotted is taken as the median of the particles as they appear on the slide.

A correction factor must be determined for each slide. The spherical droplet as it impinges on the slide becomes a convex lens, and its spread from its original shape can be calculated by determining the focal length of this lens by the method described by May.[3]

Procedure for Measuring Spread Factor of Oil Droplets on Oleophobic Slides

Use a compound high-power microscope but remove the condenser and use the flat mirror with outside light. Focus on a particle the diameter of which before correction is approximately 30 microns, and record this reading of fine-focus adjustment. Manipulate the fine-focus adjustment and mirror until some distant object (window frame) is in as sharp a focus as possible, using the drop as a lens, and record this reading of fine-focus adjustment. The difference between the two readings of the fine-focus adjustment is the focal-length change.

$$\frac{\text{Focal-length change}}{\text{Diameter of particle}} = \text{Spread factor}$$

Select the correct factor that corresponds to the spread factor as follows:

Spread	Correction	Spread	Correction	Spread	Correction
1.48	0.60	2.0	0.48	4.0	0.38
1.50	.58	2.1	.47	4.8	.35
1.55	.55	2.2	.46	5.0	.34
1.60	.54	2.3	.45	5.5	.33
1.65	.53	2.6	.44	6.0	.32
1.70	.52	2.7	.43	6.8	.31
1.75	.51	2.8	.42	7.0	.30
1.80	.50	3.1	.41	8.0	.29
1.95	.49	3.3	.40	10.0	.27

3/ May, K. R. 1945. The cascade impactor. An instrument for sampling coarse aerosols. Jour. Sci. Instr. 22: 187-195.

Example: A particle covering 2 scale divisions on the micrometer has a diameter of 30.8 microns. With a focal-length change of 103 microns, the spread factor would be 103/30.8, or 3.3. The corresponding correction factor would be 0.40. Therefore, 30.8 microns x 0.40 gives a median particle diameter of 12.3 microns.

Reporting Particle Size

The particle size of a liquefied-gas aerosol should be reported not only by mass median diameter but also by the accumulative percentage for each 5 microns in diameter up to 50 microns. This percentage can be obtained from table 1, after the correction factor has been determined. The 5-micron-diameter points should be calculated in terms of microns from the scale divisions, and then the corresponding accumulative percentage interpolated from the value in the last column.

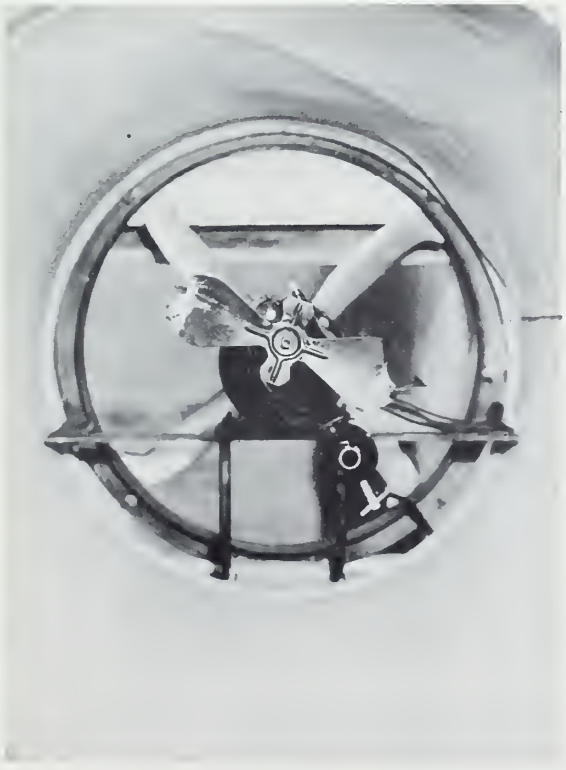

Figure 1.--Impactor for sampling aerosols, looking from the release point through the tube toward the fan.